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MODIFICATION OF PLANTING GEOMETRY TO EXPLOIT BORDER EFFECT FOR YIELD IMPROVEMENT IN RICE

MOOSSA P.P[1], THULASI V[2], RAJI P[3] & NARAYANANKUTTY M.C[4]

[1,2]*Assistant. Professor, Regional Agricultural Research Station, Kerala Agricultural University, Mele Pattambi Kerala, India,*

[3]*Professor, Regional Agricultural Research Station, Kerala Agricultural University, Mele Pattambi, kerala, India*

[4]*Associate Director, Regional Agricultural Research Station, Kerala Agricultural University, Mele Pattambi Kerala, India,*

ABSTRACT

Border effect and its effect on yield have been studied in rice plants grown in fields with different planting geometry. The objective of this study was to assess the border effect under different planting geometry. Rice variety "Jyothi" was grown on the experimental plots at Regional Agricultural Research Station, Pattambi, during 2014 and 2015 kharif season with 4 types of planting geometry I. Paired row planting with 35-15X10cm spacing (PRP-1), Paired row planting with 30-15X10cm spacing (PRP-2), Equal row spacing, planting with 20X15 cm (ERP) and Circular planting such a way that each plants get 50 cm spacing towards one side (CP). Yield and yield components were measured for outermost rows and inner rows. A significant yield difference was observed between plots. High productive tillers/hill, number of grains/panicle and high grain filling % leads to the yield increase. Significant difference in border effect was observed ranging from 21.9 to 69.6 %. The treatment PRP-1 which recorded the highest yield of 5315 kg grains/he is having the lowest border effect. Since the border effect is distributed throughout the population contributing the yield increase, this treatment is suitable for exploiting a border effect for yield improvement in rice.

KEYWORDS: Rice, Border Effect, Paired Row Planting, Yield Components & Yield Improvement

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INTRODUCTION

Rice (*Oriza sativa* (L)) is the staple food, for the majority of the global population. World rice production will have to increase by approximately one percent annually, to meet the growing demand that will arise from the future population growth and economic development (Rosegriestet al. 1995). This would depend on generating higher average yield (chessman 1999, Tilmas et al. 2002). High yielding rice varieties and agronomic practices are the two key factors for achieving this goal.

Rice productivity depends on temperature, solar radiation, moisture and soil fertility for the growth and nutritional requirement. A thick crop population leads to competition for these recourses. A number of workers have reported that maintenance of a critical level of plant population in the field is essential to obtain a maximum grain yield in rice. Counce (1987) suggested that, population density ranging from 159 to 304 plants per m^2 could produce a maximum grain yield, in a dry seeded flooded rice production system. Number of panicle per unit area is the most important component of yield, which contribute 89 % variation in yield (Kenneth et al. 1996). Planting geometry decides the structure of a given crop community. Uniform distribution, such as row configuration is commonly used in crop production and shows marked effect on grain yield of rice (Mahajan and Chamber 2011). High tillering crops like rice have a complicated response, to both inter and intra row spacing. Narrow row spacing will cause mutual shading earlier than wide row spacing, thus restricting tillering. Though, wider row spacing has high

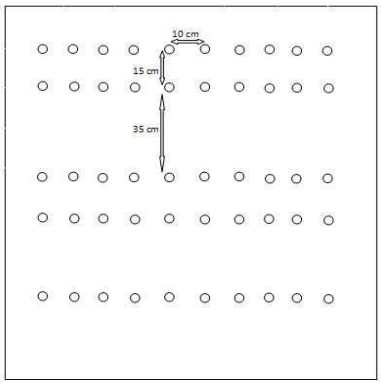
tillering, the number of plants per unit area will be less.

Border effect is the difference in performance between external and internal plants in a plot (Gomaz 1972). Higher grain yield of border row plants over the inner rows, ranges from 63 to 159% (Gomaz and Datta 1971). According to the study, conducted by Kanoe and Kiyoshi (1983), border plants showed a significant yield increase and the response is more, when the unplanted spacing is more and plant population per m^2 is high. Border effect usually occurs, when unplanted space is left between plots. Border effect increases with increase in unplanted spacing up to a limit. Lie et al. (2006) also reported border effect of 9.9 to 51.6% in 24 rice varieties. The contribution of border effect to the total yield of rice is insignificant as the number of border plants is very less compared to total plant population. Varietal difference also influences the border effect. Rice plants with large panicle and strong tillering ability exhibit greater border effect (Chen et al. 2006 and Zhang et al. 2009). In a rectangular geometry, border effect on the side with the wide hill spacing will be higher than for plants on side with the narrow hill spacing. The border effect is high for rectangular and small sized plots (Wang et al. 2013). Although there is excellent self-regulation by tillering and there exists successful artificial control by row spacing, the effect of row configuration on high-tillering crops is more ambiguous (Lampayan et al. 2010; Chauhan and Johnson, 2010).

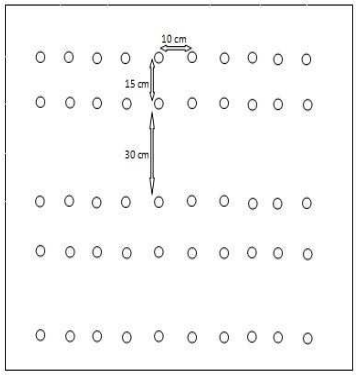
Since little efforts has been made in utilising row configuration on exploitation of border effect for productivity enhancement in rice, new planting geometry was attempted in transplanted rice..

MATERIALS AND METHODS

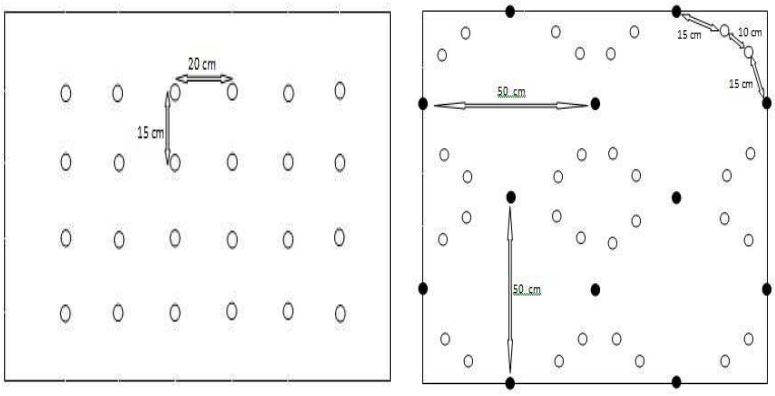
Experiments were conducted at the Regional Agricultural Research Station Pattambi, during the kharif season of 2014 and 2015, using the variety "Jyothi". Four different special arrangements were followed in these experiments. Nutrient management and other cultural practices were followed as per the package of practical recommendations for the region. The special arrangements followed in the experiment were 1. Paired row planting with 35-15X10cm spacing (PRP-1), 2. Paired row planting with 30-15X10cm spacing (PRP-2), 3. Equal row spacing, planting with 20X15 cm (ERP) and 4. Circular planting such a way that each plants get 50 cm spacing towards one side (CP) as shown in figure 1



a) PRP



b) PRP-2



c) ERP d) CP

Figure 1: a) Paired Row Planting (PRP-1), b). Paired Row Planting (PRP-2), c). Equal Row Spacing Planting (ERP) d). Circular Planting (CP)

The experiment was conducted in RBD, with five replication sand a plot size of 200 m^2.Twenty one day old seedlings were transplanted with two seedlings per hills. Pre-emergence we edicide was applied on second day after transplanting .Observations on number of productive tillers per hill, number of grains per panicle, grain filling percentage and total grains per hill was recorded from 20 plants of each replication, at the time of harvesting .Total grain and straw yield of each experimental plot was recorded. The data was subjected to statistical analysis, using ANOVA. To study the border effect, 20 plants from the border rows and inner rows were selected to analyse the yield attributes. The border effect of the treatments was calculated as follows:

$$\text{Border effect} = \frac{\text{Grain yield of border rows-Grain yield of inner row x100}}{\text{Grain yield of inner row}}$$

RESULTS AND DISCUSSIONS

The results and discussions of the experiment are arranged under two categories as given below.

Yield Response to Different Treatments

The yield and yield attributes recorded are given in table1.The paired row planting with wider spacing recorded highest values for all the parameters followed by circular planting geometry. With respect to growth characteristics like tillers/hill, grains/panicle and grain filling percentage there is no significant difference between PRP-1 and CP. The paired row planting with closer spacing recorded lowest values for all the yield attributes and grain yield. There is no significant difference in grain yield between PRP-1 and ERPG, but the straw yield of PRP-1 is significantly higher than ERP. The significant higher yield in PRP-1 is due to the high tiller production, grains per panicle and grain filling percentage. Plant density is probably the most important factor affecting tillering (Counce et al., 1992; Schnier et al., 1990). This may be the reason for low tillering in PRP-2, which got highest planting density among the treatments. Even though, the plant density in ERP (33hills/m^2) is less than PRP-1 and CP (40 hills/m^2 each), differential response due to varying row spacing in these two treatments, might have resulted in high yield, compared to ERP.

Border Effect of Different Treatments

Yield components of border rows of different treatments are given in table 2.With respect to tiller number and

grain filling percentage, there is no significant difference between treatments .The treatment ERP which recorded low grain yield (Table 1) shows highest number of grains per panicle and total grains/hill in border rows .Since the yield in border rows includes the contribution from border effect ,higher border effect for plants on side with wide hill spacing than for plants on sides with narrow hill spacing explains this response of ERP.

With respect to the yield characteristics of inner row plants (Table 3), PRP-1 reached first followed by CP. Lowest values for number of tillers /hill, grain/panicle and total grains/hill were recorded by PRP-2.The lowest grain filling percentage was recorded in the ERP. High yield characteristics in PRP-1 and CP, may be due to the wider spacing in alternate row, so that, each plant in the population gets the advantage of border effect. Spacing between rows in PRP-2 is not enough to experience border effect, but could have mutual shading resulting low yield.

The planting density varies from 33 to 44 plants/m^2between treatments. It is generally presumed that, if the planting density is less tillering will be more. The treatment with lowest planting density (ERP), did not produce a higher number of tillers which shows that more than density, special arrangement of the plant is important. Due to the peculiar special arrangement in PRP-1 and CP it produced more tillers. The border effect expressed by various treatments shows that (Table 4) it ranges from 21.9 to 69.6 %. Border effect to the tune of 62to 142% in hybrid rice was reported by Wang *et al.* (2013).

The contribution of border effect in rice is considered as insignificant as the border population, compared to total plant population is very less. The minimum yield advantage of 2.7% in a 16.6 cent plot due to border effect was estimated by Wang *et al.* (2013). In PRP-1, the border effect is very low as the border effect is distributed throughout the field without compromising the plant population, resulting in a 23 % yield increase over the general system of planting (ERP). Though the circular planting geometry also produces a significant yield increase there is a difficulty in planting and intercultural operations. Paired row planting with 35-15 cmX10 cm row and plant to plant spacing is ideal for exploiting the border effect in rice for yield improvement.

CONCLUSIONS

In this era of shrinking land recourses the only option available is to generate a higher yield from the existing land. Rice variances and agronomic practices are the two key factors to achieve the growth goals. Exploitation of border effect for yield improvement in rice is a new concept Paired row planting with 35-15cmX10 cm spacing is a planting geometry which can produce 23% higher yield over the existing spacing utilising the border effect tithe spacing can be adjusted in machines for mechanised planting. Field operations like fertilizer application and weeding also becomes easy in this system of planting. Due to the operational difficulties circular planting geometry is difficult to implement in the fields.

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Table 1: Yield and Yield Characteristics of Different Treatments

Treatments	Tiller No/Hill	Gains/ Panicle	Grain Filling %	Straw Yield(Kg/Ha)	Grain Yield (Kg/Ha)
PRP-1	8.11[a]	86[a]	85[a]	5596[a]	5315[a]
PRP-2	6.55[c]	74.6[c]	75.6[b]	4626[b]	3891[c]
ERP	7.16[b]	79[b]	77.7[b]	4338[c]	4095[c]
CP	8.08[a]	85.3[a]	82.9[a]	4865[b]	4896[b]
C.D(0.05)	0.51	2.77	3.85	263.9	204.78

Table 2: Yield Characteristics of Plants of Border Rows

Treatments	Tiller No/Hill	Gains/ Panicle	Grain Filling %	Total Grains/Hill
PRP-1	8.43	96.06[ab]	88.14	817.4[b]
PRP-2	8.27	90.42[b]	90.7	745.6[c]
ERP	8.73	101.24[a]	90.22	882.0[a]
CP	8.92	94.80[b]	87.26	849.0[ab]
C.D(0.05)	NS	5.89	NS	58.24

Table 3: Yield Characteristics of Plants of Inner Rows

Treatments	Tiller No/Hill	Gains/ Panicle	Grain Filling %	Total Grains/Hill
PRP-1	8.06[a]	88.88[a]	86.84[a]	670.2[a]
PRP-2	6.36[c]	71.38[b]	77.14[c]	459.5[b]
ERP	7.1[b]	76.48[b]	74.44[c]	520.3[b]
CP	8.1[a]	89.46[a]	82.58[b]	659.6[a]
C.D(0.05)	0.68	6.53	3.99	86.15

Table 4: Border Effect

Treatments	Number of Hills/M^2	Tiller No/Hill	Grain Yield (Kg/Ha	Border Effect(%)
PRP-1	40	8.11	5315	21.9
PRP-2	44	6.55	3891	62.3
ERP	33	7.16	4095	69.6
CP	40	8.08	4896	28.7